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資料・研究ノート

Estimation of Child Mortality, the Birth Rate, the Death Rate, and Total Fertility in the New Hebrides[1)]

by

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Introduction

One of the many populations in the world for which there are no valid data on fertility and mortality is the population of the New Hebrides. The ideal source of such information is a combination of complete and accurate registration of births and deaths and an estimate of the number of persons classified by age and sex derived from periodic censuses. Because information of this sort does not exist for such a large fraction of the world's population, there have been a number of attempts to develop estimates of birth and death rates on the basis, often, of demographic surveys in which questions about vital events within each household are asked. The success of such surveys is uncertain and recently a number of techniques have been developed (and applied) toward the estimation of various measures of fertility and mortality from data collected in population censuses or sample surveys -- data about the lifetime history of members of the population. A number of these techniques are described in Manual IV of the United Nations manuals on methods of calculation (United Nations, Department of Economic and Social Affairs, Population Studies No. 42, *Methods of Estimating Basic Demographic Measures from Incomplete Data)* and in Brass *et al. The Demography of Tropical Africa,* (1968). This brief note summarizes the results of applying these techniques to the data from the first census of the Condominium of the New Hebrides. From the internal consistency of the estimates that can be made, it is reasonably sure that a good approximation has been obtained for the birth rate, for total fertility, and for mortality in childhood. Estimates of the overall death rate and of the rate of natural increase are subject to a wider range of error.

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1) The calculations for those estimations were completed when the author was at the Office of Population Research, Princeton University. The author expresses his appreciations to Prof. Ansley J. Coale and the staff for their valuable advices.

I The Data

The census of the Condominium of the New Hebrides took place on the 28th of May 1967. New Hebrideans constitute the great majority of the population, accounting for 92.5 per cent of the total of 76,582. This report aims at estimating various demographic parameters for this ethnic group making use of the data from this single census.

The techniques employed here assume that the population is essentially a closed one. Although in the 19th century New Hebrideans were recruited to Queensland and other places many returned. In addition, this recruiting ended in the beginning of this century and therefore the effect of outmigration on the estimation of vital rates may be neglected.

Even if we suppose the population to be closed, however, there still remain some difficulties for the application of the estimation methods to the New Hebridean population: 1) Because the population is small, errors in the various ratios can be particularly large. 2) The sex-ratio of the population increases with age especially after 40 years as shown in Table 1. Similar patterns of sex-ratio are found among Indonesians and Senegalese as evident in Fig. 1. A peculiarity of the New Hebridean sex-ratio is the overall high masculinity. The values are always above 1.00 except for the age-group 20-24 which has a sex-ratio of .998. A combination of factors such as age-misreporting, greater under-numeration of females at some (or all) ages, and higher mortality among females may be responsible for the formation of this unusual sex-ratio pattern. One possibility is the

Table 1 Number of New Hebrideans by 5 year age-group and by sex

Age	Male	Female	Sex-ratio
0 - 4	6,218	5,955	1.044
5 - 9	5,734	5,387	1.064
10 - 14	4,980	4,234	1.176
15 - 19	3,813	3,425	1.113
20 - 24	2,847	2,852	0.998
25 - 29	2,845	2,748	1.035
30 - 34	2,065	1,921	1.075
35 - 39	2,049	1,936	1.058
40 - 44	1,464	1,171	1.250
45 - 49	1,540	1,143	1.347
50 - 54	1,040	794	1.310
55 - 59	808	599	1.349
60 - 64	643	413	1.557
65 -	1,346	798	1.687
N. S.	37	32	1.156
Total	37,429	33,408	1.120

Source : Census of the Condominium of the New Hebrides

effect of sex-selective "exposure" or infanticide during the infancy of the older cohorts. 3) If the deaths from the epidemics which were brought to the islands by visiting foreigners were age-selective, it would be dangerous to apply the stable population method for the estimation. The most recent epidemics were measles in 1928 and dysentery in 1931-32.

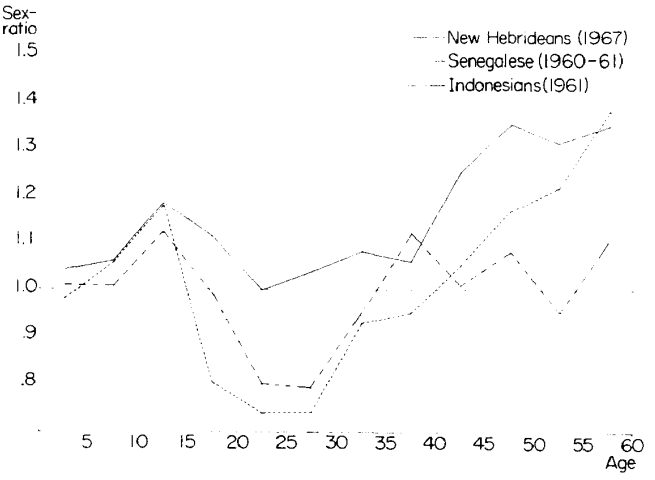

Fig. 1 Patterns of Sex-ratio among New Hebrideans, Senegalese and Indonesians

In spite of those problems, the estimation of vital rates in those small islands through Brass's technique of analyzing child survival, through model life tables, and stable population methods seems worth trying.

II Estimation of Child Mortality

The average number of children born to women in each 5 year age-group, and the average number surviving are shown in the census. (see Table 2). The values of ${}_1q_0$ ${}_2q_0$, ${}_3q_0$, and ${}_5q_0$ were obtained through the Brass method[2], and the values of the last three were also calculated following Sullivan's new device.[3] The results are shown in Table 3.

Values of e_0°'s for both sexes corresponding to the values of l_2, l_3, and l_5 were calculated for each regional model life table. (Table 4) The series of e_0° obtained from l_5 show the lowest values. As the basis for estimation of l_5 is the ratio of children

2) Cf. *Method of Estimating Basic Demographic Measures from Incomplete Data*, United Nations, ST/SOA/Series A/42, 1967, pp. 74f., and Brass *et al*, *The Demography of Tropical Africa*, Princeton : Princeton University Press, 1968, pp. 104-114.

3) Jeremiah Sullivan's work will be a part of his doctoral dessertation, not yet complete. His method to obtain ${}_2q_0$ is as following ;

$\frac{{}_2q_0}{D_2} = A + B\left(\frac{p_2}{p_3}\right)$, where A and B are the constants given, p_2/p_3 is the parity ratio of women 20-24 to women 25-29, and D_2 is proportion dead of children everborn to women of the age interval 20-24. ${}_3q_0$ and ${}_5q_0$ are calculated by similar methods. Values of A and B are as follows :

	Model life table							
	West		North		East		South	
	A	B	A	B	A	B	A	B
${}_2q_0$	1.30	−.54	1.30	−.63	1.26	−.44	1.33	−.61
${}_3q_0$	1.17	−.40	1.17	−.50	1.14	−.33	1.20	−.44
${}_5q_0$	1.13	−.33	1.15	−.42	1.11	−.26	1.14	−.32

everborn for women aged 30-34, this fact may be explained at least partly by the recent decline in infant mortality. Levels of mortality derived from l_2 and l_3 are fairly consistent with each other and we may rely upon these values as a plausible minimum indicator for child mortality in the 4 or 5 years before the census.

There are rather substantial differences in the values of e_0° according to different model life tables. Among the values estimated from l_2 and l_3, the highest e_0° is 57.9

Table 2 Average number of children born to women in each age-group and average number of children surviving

Present age of women	Average number of children born to women in each age-group	Average number of children surviving to women in each age-group
15 - 19	0.13	0.12
20 - 24	1.24	1.09
25 - 29	3.01	2.60
30 - 34	4.68	3.87
35 - 39	5.66	4.53
40 - 44	5.98	4.54
45 - 49	6.28	4.57
50 - 54	6.19	4.32
55 - 59	6.06	3.94
60 - 64	5.98	3.67
65 -	5.15	2.94

Source : Census of the Condominium of the New Hebrides

Table 3 Estimated values of ${}_xq_0$ for New Hebrideans

x	Brass Method	Sullivan's Method			
		Model West	Model North	Model East	Model South
1	.085	—	—	—	—
2	.129	.130	.126	.131	.131
3	.140	.137	.131	.137	.139
5	.178	.173	.169	.172	.174

Table 4 Values of e_0° estimated from l_2, l_3 and l_5

Estimated from :	Brass Method				Sullivan's Method			
	West	North	East	South	West	North	East	South
l_2	52.9	51.2	56.0	57.4	52.7	51.7	55.0	57.2
l_3	52.9	52.0	55.5	57.6	53.4	53.2	56.0	57.9
l_5	50.0	50.0	52.4	54.1	50.0	51.0	53.1	54.6

for the South model, and the lowest 51.2 for the North model. This wide range results from uncertainty about adult mortality, about which the census gives no useful direct evidence. It is possible that the mortality pattern in the New Hebrides differs from *any* of the four model patterns and that the true e_0° is not even encompassed between these two extremes.

III Estimation of the Birth Rate

A series of birth rates were calculated by interpolation, comparing the C(x) values of the enumerated population (Table 5), with those of the model stable population. The levels of mortality in the model stable population were determined from the values of l_2's obtained through Brass and Sullivan methods.

Table 5 C(x) values of male and female populations

Age x	Male	Female
5	.166	.178
10	.319	.339
15	.452	.466
20	.554	.569
25	.630	.654
30	.706	.736
35	.761	.794
40	.816	.852
45	.855	.887

The series of birth rates thus calculated are shown in Table 6. As the difference in the values of ${}_2q_0$ is very small between the Brass and Sullivan methods, the results are very similar.

The death rate among the New Hebrideans may well have decreased as in most other developing countries. Under such circumstances, the use of C(x) values of the older ages for the estimation of birth rate results in greater errors. Therefore, it will be safer to use the values of C(15) for the best estimation. Actually, the average of estimates based on C(15) for males and for females is a form of birth rate estimation accepted as best for many African populations.[4] Birth rates for the total population were thus calculated assuming the sex-ratio at birth to be 1.05. The birth rates thus estimated range from 44.4 to 46.6 as shown in Table 7. The best estimate is about 45.5.

IV Estimation of the Death Rate

Death rates were calculated by applying the m_x values of the model life tables to the enumerated population. The results are shown in Table 8. The death rates for the total population range from 12.4 to 15.8.

4) Brass *et al. op. cit.* pp. 168-82.

Table 6 Series of Birth Rates Estimated from C(x) Values of Male and Female Populations

Brass Method

Age x	Male birth rates estimated from C(x) of the male population				Female birth rates estimated from C(x) of the female population			
	West	North	East	South	West	North	East	South
Model level	14.8	14.2	16.2	16.7	14.8	14.2	16.2	16.7
5	40.5	40.8	41.0	40.8	43.4	43.7	43.5	43.7
10	43.2	43.6	43.3	43.4	45.9	46.6	45.9	46.5
15	44.5	45.2	44.8	45.1	45.9	46.6	45.9	46.6
20	44.0	44.8	44.3	44.6	45.5	46.3	45.6	46.3
25	42.3	43.3	42.7	43.0	45.1	46.0	45.3	46.2
30	42.4	43.5	43.9	43.3	46.5	47.5	46.8	47.8
35	41.2	42.4	41.7	42.3	46.2	47.3	46.5	47.7
40	41.2	42.7	41.9	42.6	47.9	49.2	48.5	49.8
45	39.9	41.6	40.8	41.7	47.2	48.5	47.8	49.2

Sullivan's Method

	West	North	East	South	West	North	East	South
	14.7	14.4	16.1	16.6	14.7	14.4	16.1	16.6
5	40.9	40.7	41.1	40.9	43.5	43.3	43.5	43.8
10	43.2	43.4	43.5	43.5	46.0	46.2	46.0	46.6
15	44.6	45.2	44.9	45.1	46.0	46.4	46.0	46.6
20	44.0	44.7	44.4	44.7	45.5	46.1	45.7	46.3
25	42.4	43.1	42.8	43.3	45.2	45.9	45.4	46.2
30	42.5	43.4	42.9	43.4	46.6	47.4	46.8	47.8
35	41.2	42.3	41.8	42.3	46.3	47.2	46.6	47.7
40	41.3	40.9	40.3	42.6	48.0	49.1	48.5	49.8
45	40.0	41.5	40.8	41.7	47.3	48.4	47.8	49.3

Table 7 Birth Rates for the Total Population Estimated from C(15)

Brass Method

Model life table	Estimated from C(15) of the male population	Estimated from C(15) of the female population	Average
West	45.9	44.4	45.2
North	46.6	45.0	45.8
East	46.2	44.4	45.3
South	46.5	45.0	45.8
Sullivan's method			
West	46.0	44.5	45.3
North	46.6	44.9	45.8
East	46.3	44.5	45.4
South	46.5	45.0	45.8

Table 8 Death Rates Estimated by Applying m_x Values of the Model Life Tables

	Model life table	Male	Female	Total
Brass Method	West (level 14.8)	15.0	12.5	14.6
	North (level 14.2)	16.1	13.6	15.8
	East (level 16.2)	13.6	10.9	13.0
	South (level 16.7)	12.8	10.6	12.4
Sullivan's Method	West (level 14.7)	15.1	12.6	14.8
	North (level 14.4)	15.8	13.3	15.5
	East (level 16.1)	13.7	11.0	13.2
	South (level 16.6)	12.9	10.8	12.6

V Estimation of the GRR and TF

Gross reproduction rates were calculated by interpolation using the figures attached to the tables of regional model stable populations, assuming the mean age of the fertility schedule ($\bar{m}$) to be 30.0.[5] Total fertilities were obtained assuming the sex-ratio at birth of 1.05.

Table 9 GRR and TF Estimated from C(15), Assuming $\bar{m}$ of 30.0, and Sex-ratio at Birth of 1.05

	Model stable population model (level)	GRR estimated from C(15) of male pop.	female pop.	average	TF estimated from C(15) of male pop.	femald pop.	average
Brass Method	West (14.8)	3.19	3.39	3.29	6.54	6.95	6.75
	North (14.2)	3.28	3.46	3.37	6.72	7.10	6.91
	East (16.2)	3.24	3.40	3.32	6.63	6.97	6.80
	South (16.7)	3.29	3.48	3.39	6.74	7.14	6.94
Sullivan's Method	West (14.7)	3.20	3.40	3.30	6.56	6.96	6.76
	North (14.4)	3.28	3.45	3.37	6.73	7.03	6.88
	East (16.1)	3.24	3.41	3.33	6.65	6.98	6.82
	South (16.6)	3.28	3.49	3.39	6.78	7.14	6.96

TF ranges from 6.75 to 6.96 according to the different levels of four regional model life tables. Those values exceed 6.28, the average parity of women aged 45-49, a figure that is usually understated. Thus, the estimation seems reasonable. TF obtained from p_3^2/p_2 is 7.31.[6] Hence we may be fairly sure that total fertility in the New Hebrides is slightly below or slightly above seven children.

5) Application of the standard age patterns of female marital fertility rate produces $\bar{m}$ of 30.5, while $\bar{m}=2.25\times(p_3/p_2)+23.95$ produces $\bar{m}$ of 29.4. Thus, $\bar{m}$ was estimated to be about 30.0. (cf. *Method of Estimating Basic Demographic Measures from Incomplete Data*, p. 24.)

6) Cf. *ibid.* p. 34.